

PCT

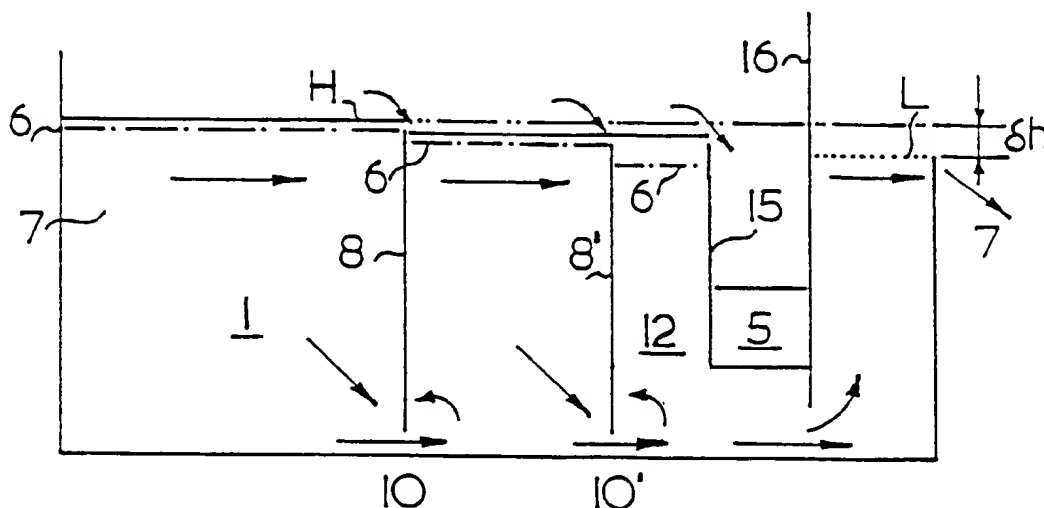
WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>5</sup> : C02F 1/40, B01D 17/028 E03F 5/16</p>	<p>A1</p>	<p>(11) International Publication Number: <b>WO 94/04464</b> (43) International Publication Date: 3 March 1994 (03.03.94)</p>
<p>(21) International Application Number: PCT/EP93/02289 (22) International Filing Date: 24 August 1993 (24.08.93) (30) Priority data: 9201499 24 August 1992 (24.08.92) NL 9300300 2 February 1993 (02.02.93) NL (71) Applicant (for all designated States except US): LEMACON TECHNIEK B.V. [NL/NL]; Poort Van Midden-Gelder- land Groen 26, NL-6666 LP Heteren (NL). (71)(72) Applicant and Inventor: VAN SCHIE, Louis [NL/NL]; Van Leeuwenhoeklaan 55, NL-5252 CB Vlijmen (NL).</p>		<p>(74) Agent: MERKELBACH, B.; P.O. Box 1080, NL-2260 BB Leidschendam (NL). (81) Designated States: US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: METHOD AND DEVICE FOR THE SEPARATION OF A CONTAMINATED TOP LAYER



(57) Abstract

For the separation of a contaminated floating top layer of oil or oil substances, a continuous laminar flow is created on or near the surface, by placing a number of baffles (8, 8') in the path of the flowing liquid (V) as it moves through a tank (1). The total amount of liquid flowing through the tank (1) is now adjusted in such a way that the correct control of the upper laminar flow (5) and the dominant more turbulent lower flow near the bottom (9) of the tank (1) produces a controllable constant difference in height (delta h). This total difference in height (delta h) can also be attained by cascade operation.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FR	France	MR	Mauritania
AU	Australia	GA	Gabon	MW	Malawi
BB	Barbados	GB	United Kingdom	NE	Niger
BE	Belgium	GN	Guinea	NL	Netherlands
BF	Burkina Faso	GR	Greece	NO	Norway
BG	Bulgaria	HU	Hungary	NZ	New Zealand
BJ	Benin	IE	Ireland	PL	Poland
BR	Brazil	IT	Italy	PT	Portugal
BY	Belarus	JP	Japan	RO	Romania
CA	Canada	KP	Democratic People's Republic of Korea	RU	Russian Federation
CF	Central African Republic	KR	Republic of Korea	SD	Sudan
CG	Congo	KZ	Kazakhstan	SE	Sweden
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovak Republic
CM	Cameroon	LU	Luxembourg	SN	Senegal
CN	China	LV	Latvia	TD	Chad
CS	Czechoslovakia	MC	Monaco	TG	Togo
CZ	Czech Republic	MG	Madagascar	UA	Ukraine
DE	Germany	ML	Mali	US	United States of America
DK	Denmark	MN	Mongolia	UZ	Uzbekistan
ES	Spain			VN	Viet Nam
FI	Finland				

Method and device for the separation of a contaminated top layer.

5 The invention relates to a method for the continuous separation of a floating layer of light material (upper flow), such as oil or material particles saturated with oil and/or covered in oil, with respect to a heavier liquid supporting layer (lower flow), such as water, on which the floating layer is situated, by making use of a difference in level, to be maintained, between the inflow side located at a higher level in a device for the separation, and the discharge side, located at a lower level on the  
10 said device, for the removal of the largely separated supporting material (lower flow), and by making use of an overflow unit for the material to be separated (upper flow) into the collection chamber for this, whereby the top side of this overflow unit extends no further below the common level of the liquids fed in than the minimum or more or less stable continuous thickness of the floating layer (upper flow), which  
15 can be removed from the collection chamber using means that are known per se. The invention also relates to a device for the application of the aforementioned method.

In connection with the increasing stringency of requirements set by national governments with regard to the discharging of waste substances into surface waters,  
20 various methods and devices had already been proposed, all with the purpose of purifying the waste water before it is discharged into surface waters. If intolerable pollution of surface waters would occur, e.g., shipping disasters or the like, the requirement is also set that the pollutor must immediately perform effective cleaning measures.

25 The method has the purpose of bringing about faster treatment and, with regard to the attainment of the optimum separation of the material flows (upper and lower flows) in the flow range of both of the material flows that are fed in from the said inflow side to the overflow unit, for example floating oil and water, it ensures that a mainly laminar flow pattern is maintained in one and the same direction of passage  
30 above and below the separation layer (of the upper and lower flow) of the liquids, while, up to a considerable distance below the overflow unit, by means of a baffle placed perpendicular to the main flow, the flow pattern in the vertical direction (lower

- 2 -

flow) is deflected upwards and downwards, parallel to the baffle, at a relatively low flow speed, whereby, in downward direction, a small to considerable part of the main flow of the supporting material (lower flow) is able to flow away to the aforementioned discharge side with a reduced liquid level, through at least one  
5 relatively narrow passage opening, for example, in the form of a round or oval opening, or, for example, a passage gap and, furthermore, an increasing thickness of the floating layer is maintained behind the overflow unit, with a simultaneous choice between controlling the liquid flowing through the device, and/or the amount of the floating layer removed from the collection chamber per unit of time and/or the  
10 height of the overflow unit, and/or the size of the passage opening, e.g. of a gap, in order to attain the optimum stable flow pattern.

The active level difference employed by the invention may possibly be spread over a number of liquid-level steps, to which end a cascade-overflow system could be employed. According to the invention, this occurs because the liquid flows are  
15 carried along two or more baffles with each of the associated overflow units at different heights, all arranged in such a manner that the differences in liquid levels in front of and behind each baffle are each controlled to a stable flow pattern which gives rise to this cascade-overflow system.

When this method is applied on board of a ship and, e.g. a (crude) oil slick has to  
20 be tackled, it may first be necessary to ensure that the oil slick does not sink to the sea bottom during bad weather or, e.g., that undesired emulsification does not occur. In those cases it may first be effective to bind the oil (or tar) to a number of supporting particles, e.g., plastic-foam particles. In that case, according to the invention, the upper floating layer consists of light plastic-foam balls or a similar  
25 material with a relatively large surface area which is adhered to and/or penetrated by the material to be separated.

According to the invention, a device for separating one floating lighter material component from a second heavier material component, by making use of the method, consists of a passage reservoir through which flowing liquid passes, which  
30 flowing liquid has an upper flow, in which the lighter material components (oil or particles with oil attached to them) are found, floating on the lower flow, and which passage reservoir consists of a channel-shaped tank that, e.g., is open or closed on

- 3 -

the top side and is provided with a front wall perpendicular to the direction of flow, which is provided with an inlet, as well as a rear wall, likewise perpendicular to the direction of the flow, for removal or transfer of the lower flow and, furthermore, between the front and rear wall, one or more baffles are mounted, whereby each

5 baffle that reaches the bottom of the tank is provided with at least one passage opening, e.g., comprising a number of round passage openings or, e.g., at least one passage gap extending across the tank, and also forms an overflow unit for the layer to be separated, one and the other in such a way that the liquid level of the lower flow in the reservoir compartment upstream, of a baffle, differs considerably from the

10 liquid level of the lower flow in the reservoir compartment downstream, of a baffle. Basically, this set-up is intended to maintain a laminar flow pattern within the range of the top layers of the upper and lower flow, and to guarantee a turbulent flow pattern within the range of the bottom layer of the lower flow, which produces a remarkably effective result, as has been seen in practice.

15 For a stationary device, it will be possible to obtain favourably a stable flow pattern for a given flow; on the other hand, a mobile device for use in open water with, e.g., beating waves, would produce more problems, in which case it would be advisable to fit the device according to the invention with adjustable first means, in order to, if necessary, repeatedly control the height of an overflow unit for the upper flow to

20 be separated, in combination with adjustable second means for the control of the size of the aperture of the passage opening and/or passage gap close to the bottom of the tank.

In an especially favourable embodiment, the device according to the invention is equipped in such a way that a perforated plate, of which the diameter of perforation

25 e.g. increases in size in the down-stream flow direction, is mounted more or less horizontally in each upstream compartment of the tank to promote the maintenance of a laminar flow pattern immediately within the range of the separation layer between the upper and lower flow.

In each case, according to the invention, it is possible to provide specially formed

30 compartments, if a number of them are formed by an enlarged honeycomb-like structure provided with means for adjusting the distance with respect to the bottom of the tank as well as of the height of the upper wall sections of the said

- 4 -

honeycomb-like structure, which function simultaneously as overflow units. In addition, the top side could for instance slope downwards, together with the total course of the liquid level difference that has to be maintained between the inflow side and the transfer side of the tank.

5 Furthermore, according to the invention, it may be useful to promote the separation of the top material layer at the point of a baffle. Amongst other ways, this can be achieved by a baffle near the overflow unit provided with a curved upward-sloping edge sloping downwards in downstream direction at its back, to subsequently change into a vertical section again slightly bent to slope upwards in the  
10 downstream direction near the bottom of the tank, in order to obtain a venturi effect. In another preferable embodiment, a baffle is provided with a curved rising edge near the overflow unit which edge extends downwards as a vertical section, after which a section is bent through a sharp angle in the direction of the flow and is preferably provided with at least one passage opening, e.g., comprising a number  
15 of round passage openings and/or at least one passage gap.

Numerous tests with the device have shown that the controllability of its operation can be considerably improved if, taking into consideration the composition of the material flows to be separated, a number of further technical measures are taken. The fluctuations in the flow of the composite material flows being fed in can be  
20 controlled, and with it the device's efficiency, if the flow of the discharge of the separated lighter material flow is determined by positioning a movable first valve unit and the flow of the discharge of the cleaned material flow is determined by positioning a movable second valve unit.

The positions of both valve units can now be simply controlled so that each movable  
25 valve unit is connected to a fixed transverse section of the tank, for example a baffle or rear wall, by means of a hinged joint. This is preferably formed by an oblong, flexible strip of material, especially one made of an elastomer (rubber), which is attached in such a way that it seals along one of its long sides to the fixed transverse section of the tank, while the other long side is attached so that it seals  
30 to a rigid strip-shaped valve unit.

It has become apparent that it is advantageous if the movable seal along the height of the valve unit, between the side wall and the transverse section of the tank, is

- 5 -

formed by the hinged strip of the elastomer material that runs sideways over the total length of the valve unit to the side wall of the tank. In order to also promote the mobility of a valve unit with respect to the wall of the tank, while maintaining the intended sealing effect, it is desirable to interfit a strip of sealing elastomer material at the position of the side wall between the movable ends of a valve unit and that fixed side wall, along the height of the valve unit, the rigidity of which only extends to a certain distance away from that side wall. In an especially favourable embodiment of construction, the hinged seal of the valve unit is formed by one material strip of the elastomer material of which the height corresponds to that of the valve unit and of which the length corresponds with at least the length of the total length of the valve unit, plus the valve's clearance or free distance of travel from the top of the valve unit with respect to the hinged joint.

Depending on the required setting for both of the valve units, means can be provided to adjust the position of the valve units separately with respect to each other. Another favourable embodiment arises if, once both valve units have been set in their common positions, they can be operated by means of one common coupling unit that is adjustable.

In addition, it is an advantage if the adjustment of the coupling unit is attained by means of a float, whereas after the tank the cleaned second material component flows into an extra container, the level of which is then affected by the float and the position of a valve unit connected to it.

When using the device according to the invention for material flows that contain material particles that can cause blockages in the narrow passage openings, the removal of the particles is facilitated by providing a baffle with a number of passage openings situated next to one another near the bottom passage gap, whereby each opening is formed out of the baffle's sheet material, namely by making a vertical cut and then bending the sheet outwards on both sides of the cut, along fold lines, over a certain distance, in the direction of flow, in order to create a triangular self-cleaning passage opening.

An excessively low temperature in the immediate vicinity of the overflow area of a baffle and/or a valve unit can also cause a blockage, as a result of the coagulation of the floating material components, amongst other things. This kind of blockage

can be removed if, e.g., the device according to the invention is provided with a heating element, in which case a sheet-form section of the tank or of a valve unit is constructed with a double-wall and a heating element is fitted inside that double wall, such as a steam-heated element or an electric element.

5 Other blockages may occur in the tank and in front of or close to the valve units or overflow baffles. In order to, avoid these blockages or accumulations of the floating material component, as much as possible means are provided that consist of a slowly rotating scraper unit, particularly a sweeping brush, which has the purpose of removing any undesired accumulation of larger particles in front of the valve unit,  
10 in the event of a floating layer in a compartment of the tank not having a uniform composition (e.g. different particle sizes), by stopping the accumulation of particles near the top side of a valve unit, which means are furthermore set up in such a way that the particles are not swept past or over the greatest height of the said valve unit.

15

Some embodiments of the invention are explained below in more detail below by means of the drawing.

20

Fig. 1 is a schematic diagram of a longitudinal section of an extremely simple construction of a separator according to the invention;

Fig. 2 is a schematic diagram, likewise of a longitudinal section, of a cascade type of construction for a separator according to Fig. 1;

Fig. 3 is a schematic diagram of a longitudinal section of an industrial oil separator according to the invention;

25

Fig. 4 is a crosssectional view of a baffle having an altered construction;

Fig. 5 is a schematic diagram of a perforated horizontally positioned baffle;

Fig. 6 shows a large-scale cross-sectional view (mid-section lengthwise) of a device according to the invention which is shown in Fig. 7 in perspective on a reduced scale;

30

Fig. 8 shows a large-scale cross-sectional view (mid-section lengthwise) of another device according to the invention with a sweeper device which is shown in Fig. 9 in a reduced perspective scale (like in Fig. 9A-9D relating to it);



- 7 -

- Fig. 10 shows a detail of the side connection or seal between a valve unit and the side wall of the tank in a device according to the invention;
- Fig. 11 shows the bottom side of a baffle in which self-cleaning passage holes are provided;
- 5 Fig. 12 is a schematic diagram of a single-walled baffle on which a heating element with a flat construction is fitted.

In various figures, the same reference numbers indicate identical components in different embodiments.

- 10 Figure 1 is a cross-section of a canal-shaped tank which is open at the top, with external dimensions that can range from half a metre to several metres, e.g. when used for ships. The main flow direction V is indicated on the inflow side 2 of the tank 1. There is a transfer wall 4 on the discharge side 3 of the tank 1. The upper flow 5 (oil or grease) and the separate lower flow 7, visible through a separation layer 6,
- 15 flow from left to right in the tank 1. Depending on the number of parameter values, e.g. the flow volume, nature and size of the product to be separated, the height, width and length of the tank 1 for separation of specific material flows, a baffle 8 is placed between the inflow side 2 and the discharge side 3. In this embodiment, the height of the baffle 8 is approximately at the liquid level of the separation layer 6,
- 20 while on the bottom side 9 of the tank 1, over its full width, a passage opening in the form of a passage gap 10 is left open. While it is desirable to maintain a laminar flow pattern in the upper part of the tank 1 for effective separation of the various material flows (oil or grease and water), it is intended to create a turbulent flow pattern in the lower part of the tank 1 at the passage gap 10, also having the
- 25 purpose of promoting the stability of a thicker floating layer 11 in the collection chamber 12 behind the baffle 8.

- Furthermore, the arrows in the figure are used to provide an extremely systematic indication of the subsequent path of the upper flow 5 or the lower flow 7. The height of the transfer wall 4 is lower than the height of the baffle 8, in such a way that there
- 30 is a constant difference in height  $\delta h$  between the highest point H of the upper flow 5 and the highest point L of the lower flow 7, so that this constantly maintained difference causes the (contaminated) upper flow 5 to be pushed over the overflow

- 8 -

13 of the baffle 8 into the collection chamber 12, where it is accumulated to form a thicker layer 14.

Figure 1 shows a standpipe 15 that opens in the collection chamber 12 at such a level under the thicker layer 14 that the thicker layer 14 can be removed via the standpipe 15. The standpipe 15 can be closed at its bottom and then be emptied, e.g., by means of a suction connection to the suction side of a pump, or it can run into a collection chamber (for oil) underneath the tank 1 from where it can be pumped. The invention, however, does not relate to the removal of the upper flow 5, so that relevant constructional details are not further considered. In Figure 1 the standpipe 15 is mounted to a supporting baffle 16 and the turbulent lower flow in the collection chamber and behind the supporting baffle 16 ensures that the difference in level  $\delta h$  is maintained on the one side and, on the other side, partly because of this, that the thickness of the upper layer 5 behind the transverse baffle 8 increases on account of the laminar accumulation.

The passage gap 10 in Figure 1 can sometimes cause blockages, depending on the further contamination of the liquid materials being treated and it has become apparent that, as an alternative, this passage gap 10 can be completely shut off, provided another sort of passage opening is provided near the bottom of the tank 1, for instance by means of a horizontal row of round or oval holes or perforations or a combination of these, with a number of passage gaps that do not extend across the full width of the tank. These may possibly be provided horizontally and/or vertically in a baffle. It has become apparent that this separation tank 1 operates extremely effective with various flowvolumes in separating oil-containing waste water, in which case a difference in level of 10 mm was used.

In Figure 2, showing a larger tank, a second baffle 8' is shown and the difference in level  $\delta h$  can be divided over a cascade or made even larger. Like the embodiment shown in Figure 1, use can be made of means (not shown here) for controlling the height of the overflow units (13 and 13', and means for controlling the whole or part of the size of the passage openings 10 and 10', whereby, in combination with other tank parameters, it becomes possible to obtain or maintain any required laminar or turbulent flow pattern, which will, of course, be highly

- 9 -

dependent on the composition of the material to be "purified". In the event of the tank 1 being installed on board of a ship, the speed of the flow will be linked to the vessel's speed and, consequently, more and different parameters will play a role that will affect the adjustment for the creation of a laminar or turbulent flow pattern through the tank 1.

Figure 3 shows a separator of which a tank 1 is provided with differently shaped baffles 17 and 18. A baffle has a largely vertical section 19 that is curved at one part 20 to the left near the top side over an obtuse angle against the direction of the flow V. The end that the liquid flows against 21 is rounded off, which promotes the accumulation of the upper flow 5 that is being separated. In a downward direction the vertical section 19 changes into a curved end section 22 that promotes a venturi effect and consequently the creation of a turbulent flow pattern.

Figure 4 shows another embodiment of a baffle. The end 21 that the liquid flows against can be the same as that of the baffle shown in Figure 3, however, it extends downwards as a vertical section 23, after which a section 24 is bent through a sharp angle in the direction of the flow and continues on to the lower end 25 which is again intended to create a venturi effect.

Figure 5 shows a perforated baffle in perspective which is intended to be highly effective to maintain the laminar flow pattern near the separation layer 6. As indicated, the pattern of the perforations 27 can consist of regular shapes, e.g., round or oval holes, teeth, rectangular slot perforations or, as in the drawing, triangular perforations, with the apex pointing against the direction of the flow V. The dotted line in Figure 5 shows the toothed construction 28. It has also become apparent that the latter perforations, which in shape diverge in size in the direction of the flow, can make a considerable contribution to the maintenance of the desired laminar flow pattern.

On the basis of the possibilities indicated, an expert in fluid mechanics will certainly see that no technical restriction exists with regard to the application, the positioning, the number of perforations to be made and the form of the flow profiles for the

- 10 -

upper flow, or with regard to the perforated baffle, which together with the various forms of transverse baffles contribute to the further realization of the invention.

5 In Figures 6 and 7, the material to be continuously separated, hereinafter referred to as oil or water respectively, is fed into the tank 31 as a common flow volume of oil with water that follows the main flow V, and the levels in the subsequent compartments of the tank 31 are in fact adjusted by the position of the valve unit 32 for the oil discharge, or the valve unit 33 for the water discharge. The first baffle 34 consists of a vertical sheet section, the lower end of which forms a passage gap 35 with the bottom 36 of the tank, and the upper end has a curve 37 and a sheet section 38 that slopes away in the direction of the flow. This sheet section 38 has V-shaped notches 39 that promote a laminar flow. The second transverse baffle 40 has a first bend 41 against the direction of the main flow V followed by a second bend 42 in the direction of the main flow V, and then a curve 43 which is followed by a steeper sloping sheet section 44. This sloping sheet section 44 also has V-shaped notches 45 which are likewise intended to promote a laminar flow pattern. The fixed baffles 34 and 40 in the tank 31 are seal-jointed to the side wall and the height of the curves 37 and 43 can be more or less equal. In Figure 6, the oil-collection chamber 46 is connected to an oil-discharge connection 47 and, on the inflow side of the collection chamber 46, there is a first hinged valve unit 32. The hinge consists of a strip 48 of elastomer rubber material that extends over the entire width of the tank and is clamped to the edge of the collection chamber 46 by means of a narrow metal strip 49. This metal strip 49 is fitted on both sides with a sheet section 50 bent through 90°, which is fixed to the inside wall of the tank 31. The clamping or the fastening can be achieved using fastening elements, e.g., blind rivets, nuts and bolts, or the like, which are not further described here. The valve unit 32, consisting of a rigid metal strip 51 with a folded edge 52, the clamped rubber strip 48 and a second metal strip 53, can be operated using two hinging lever arms 54 joined together by means of a connecting rod 55. Valve unit 33 is operated in a similar manner and has the same construction as described before for valve unit 32. The same parts are shown in the drawing with the same reference numbers provided with an apostrophe. Depending on the positions of the valves 32

SUBSTITUTE SHEET

- 11 -

and 33, as set beforehand by the operator, the lever arms 54 and 54' can then be joined by a pair of common adjusting rods 56 and 56' which are provided through passage apertures 57 and 57' on the top end of each of the lever arms 54 respectively 54'. Close to these passage apertures, the adjusting rods are threaded so nuts (not shown here) can be used to fix the position of each lever arm 54 respectively 54'. On the discharge side of the purified water, a float unit 58 is rigidly attached to valve unit 33 by means of a holder 59 and thereby controls the position, depending on the level in the extra compartment 60 fitted after the tank 31, which is only shown schematically.

With a continuous inflow of the material components to be separated, the required height differences between the oil layer and the water level have to be set by first adjusting the valve units 32 and 33, after which the common connection between the lever arms 54 and 54' can be fixed by means of the adjusting rods 56 and 56', so that the operating mechanism is operated continuously via the float 58.

In Figure 10 a detail is shown of the side wall 61 of the tank 31, showing the seal-jointing to the ends of valve unit 32. The same applies to the seal-jointing of valve unit 33. The strip 48 of elastomer material extends sideways so far beyond the rigid strip 51 of valve unit 32 that the remainder allows sufficient distance of travel for valve unit 32 to be free to move in an upstream and downstream direction. The end of strip 48 is then fastened by means of a clamping strip 50 to the side wall, using, e.g. nuts and bolts (not shown on the drawing).

Figures 8 and 9 show another embodiment for a tank 31' in which a baffle 34' is fitted that forms a passage opening 35' with the bottom 34' of the tank 31'. The collection chamber 46', the bottom of which inclines towards the middle, is further provided with a pipe connection 63 for discharge of the separated material component. Moreover, the front wall 64 of the collection chamber 46' is fitted with a valve unit 32' and the open rear side 65 has a bend 66, after which the end 67 of the sheet wall is bent through an angle in the direction of the main flow V and serves to transfer the heavier material component, water. The movable valve unit 33' is fitted to the baffle 68 and the attachment of the flexible hinged joint, formed by the

- 12 -

strip 48, is the same as used in the embodiment shown in Figures 6, 7 and 10. The common adjustability of the position of both valve units 32' and 33' and their common connection, as well as the operation with the float unit 58', is likewise as in the embodiment described in Figures 6 and 7. The special form of embodiment  
5 of Figures 8 and 9 consists of a sweeper unit A fitted to the tank 31', which consists of a sweeper roller 69 and a motor 70, as well as a pinion 71 driving a gear wheel 73 via a chain 72 on the shaft 74 to which the sweeper roller 69 fitted.

If a flow of floating material containing particles of irregular sizes is provided, the  
10 particles concerned could result in blocking the continuous throughput over the folded edge of the sheet or the valve unit 32', however this is avoided by the use of the slowly rotating sweeper roller 69 which keeps the particles moving. The sweeper unit A is shown in more detail in the Fig. 9A-9D. The frame of the sweeper  
unit consists of side plates 75, which are attached to a cross bar 76, in which the  
15 shaft of the sweeper roller 69 is fitted, as well as the shaft of the motor 70. Holes for bolts are provided in the side plates. On both sides of the side wall of the tank 31 there are bolt slots 77 which enable the sweeper unit A to be set up as required with respect to the baffle 34' by means of bolts 78.

20 Figure 11 is a schematic diagram showing a self-cleaning passage opening D. A number of passage openings D is made in the baffle 34 which may possibly be combined with a passage gap 35. Each passage opening is formed out of the baffle's sheet material by making a cut 79 along a vertical line X and then bending the sheet outwards on both sides of the cut, along the fold lines Z, over the distance  
25 Y, in the direction of flow, in order to create a triangular self-cleaning passage opening. In the absence of a passage gap 35, this forms an opening split that converges from the centre to the sides near the bottom 36, while in the upward direction a passage opening is produced in the form of an isosceles triangle, indicated by D. The boundary of the total passage opening D lies behind the plane  
30 of the drawing. Together, the four parameters formed by the number of passage openings, the distances X and Y and the angle of bending along the lines Z, can produce a series of specific baffles for repeatedly purifying a series of particular

- 13 -

contaminants with, e.g., various particle sizes.

5 Figure 12 illustrates by way of example how a baffle 80 can be fitted with a heating element 81, shown here schematically, in order to ensure that the surface tension at the average temperature of the material components flowing through does not form an obstacle to the continuous separation. E.g., coagulation of the material components could occur at an excessively low temperature and an accumulation of any such coagulated particles could impede the passage and consequently the cleaning process.

10 It does not matter whether the heating element is integrated in or on the baffle 80, like, for example, the sheet-shaped heating element shown in Figure 12, or whether a hollow baffle for the installation of a heating element is used. In the case of a fixed baffle, a connection for an electric element or a steam-heated element can be provided for through the tank's side wall 82. A heating element's position and  
15 construction and/or its regulation are entirely dependent on the desired effect of the heating element.

- 14 -

To be inserted in the text on page 7, line 6 of the description:

[element with a flat construction is] fitted;

5 Fig. 13 is a schematic diagram of a similar device as shown in Fig. 6 in which there is another arrangement of the fixed baffles and the float adjusted valve-baffle. The water level is here shown in its lowest position;  
Fig. 14 shows a schematic diagram of the device of Fig. 13 wherein the water level is shown at its highest level.

10 To be inserted in the text on page 13, line 17:  
Figures 13 and 14 both illustrate another upstream arrangement of a float adjusted valve 132 in a tank 131 whereas in a downstream direction a first fixed baffle 134 is positioned behind the float adjusted valve 132 and a second fixed baffle 140 is positioned furthermore in a downstream direction. Both figures 13  
15 and 14 clearly show that the top section 137 of baffle 134 and the top section 143 of baffle 140 differ slightly in a horizontal plane, thereby enabling to collect the floating material from its supporting water layer. The float adjusted valve 132 is operated e.g. in a way as described for the device of fig. 6 and this makes the device suitable for fluctuating water/oil levels or the like. Apart from the  
20 demonstrated adaptability of the device with respect to actual fluctuating water/oil levels it is remarked that the invention could also be realized by lowering or raising the entire device and/or by partly rocking it around a chosen point of rotation to achieve the same operational advantages. In the latter event the adjustability of the float valve could also be adapted to the upward and downward  
25 movement of the device itself in order to establish an efficient coordination for the perfect operation of the device.

Insert new claim 23:



- 15 -

## Claims

1. Method for the continuous separation of a floating layer of light material (upper flow) (5), such as oil or material particles saturated with oil and/or covered in oil, from  
5 a heavier liquid supporting layer (lower flow) (7), such as water, on which the floating layer (5) is situated, by making use of a difference in level ( $\delta h$ ), to be maintained between the inflow side (2), located at a higher level in a device for the separation, and the discharge side (3), located at a lower level on the said device, for the removal of the largely separated supporting material (lower flow) (7), and by making use of an  
10 overflow unit (13) for the material to be separated (upper flow) (5) into the collection chamber (12) for this purpose, whereby the top side of this overflow unit (13) extends no further below the common level of the liquids fed in than the more or less stable continuous thickness of the floating layer (upper flow) (5), which can be removed from the collection chamber (12) using means known per se, characterized in that, with  
15 regard to the attainment of the optimum separation of the material flows (upper and lower flows) (5, 7) in the flow range of both of the material flows fed in from the said inflow side (2) to the overflow unit (13), for example floating oil and water, it ensures that a mainly laminar flow pattern is maintained in one and the same through-going direction above and below the separation layer (6) (of the upper and lower flow) of the liquids, while, up to a considerable distance below the overflow unit (13), by means of  
20 a baffle (8) placed across the main flow, the flow pattern in the vertical direction (lower flow) is deflected upwards and downwards, parallel to the baffle (8), at a relatively low flow speed, whereby, in the downwards direction, a small to considerable part of the main flow of the supporting material (lower flow) (7) is allowed to flow away to the  
25 aforementioned discharge side (3) with a reduced liquid level, through at least one relatively narrow passage opening (10), e.g., in the form of a round or oval opening, or, e.g., a passage gap and, furthermore, an increasing thickness of the floating layer is maintained behind the overflow unit (13), with a simultaneous choice between controlling the liquid flowing through the device, and/or the amount of the floating  
30 layer (14) removed from the collection chamber (12) per unit of time and/or the height of the overflow unit (13), and/or the size of the passage opening (10), in the form of a passage gap, e.g., in order to attain the optimum stable flow pattern.

2. The method according to claim 1, characterized in that the liquid flows are carried past two or more baffles (8, 8') with each of the associated overflow units (13) at different heights, all arranged in such a manner that the differences in liquid levels in front of and behind each division plate (8, 8') are each adjusted to obtain a stable flow pattern which gives rise to a cascade-overflow system.

3. The method according to one of the foregoing claims, characterized in that the upper floating layer consists of light plastic-foam balls or similar material particles with a relatively large surface area which is adhered to and/or penetrated by the material to be separated.

4. A device for separating one floating, lighter material component, from a second heavier material component, while using the method according to one of the foregoing claims, consisting of a passage reservoir through which the flowing liquid passes, which flowing liquid has an upper flow (5), in which the lighter material component (oil or particles with oil attached to them) is found, floating on the lower flow (7), and which passage reservoir consists of a channel-shaped tank (1) that is, e.g., open or closed on the top side and is fitted with a front wall (2) perpendicular to the flow, which is provided with an inlet, as well as a rear wall (3), likewise perpendicular to the flow, for the removal or transfer of the lower flow (7) and, furthermore, between the front and rear wall (2, 3), one or more baffles (8 8') are provided, whereby each baffle (8 8') that reaches the bottom (9) of the tank (1) is provided with at least one passage opening (10), e.g., comprising a number of round passage openings or, e.g., a passage slot extending across the tank (1), and also forms an overflow unit (13) for the layer to be separated (5), one and the other in such a way that the liquid level of the lower flow (7) in the reservoir compartment upstream, of a baffle (8 8'), differs considerably from the liquid level of the lower flow (7) in the reservoir compartment (12) downstream, of a baffle (8 8').

5. A device according to claim 3, characterized in that adjustable first means are provided, in order to, repeatedly control the height of an overflow unit for the upper flow to be separated, in combination with adjustable second means for the control of the size of the aperture of the passage opening and/or passage slot (10) close to the bottom (9) of the tank (1).

6. A device according to one of the foregoing claims 4-5, characterized in that a perforated sheet (26), of which e.g. the diameter of perforations e.g. increases in size in the downstream flow direction, is mounted more or less horizontally in each upstream compartment of the tank to promote the maintenance of a laminar flow pattern immediately within the range (reach) of the separation layer (6) between the upper and lower flow (5, 7).

7. A device according to the foregoing claims 4-6, characterized in that a number of the tank's (1) compartments are formed by an enlarged honeycomb-like structure provided with means for adjusting the distance with respect to the bottom of the tank as well as of the height of the upper wall sections of the said honeycomb-like structure, which function simultaneously as overflow units (21).

8. A device according to one of the foregoing claims 4-6, characterized in that a baffle (8) near the overflow unit (21) is provided with a curved upwardly sloping edge (21) that then slopes downwards at its the back (20), to subsequently change into a vertical section (19) that is again slightly bent (22) to slope upwards again in the downstream flow direction near the bottom (9) of the tank (1), in order to obtain a venturi effect.

9. A device according to one of the foregoing claims 4-6, characterized in that a baffle (8) is provided with a curved rising edge near the overflow unit (21) which edge extends downwards as a vertical section (23), after which a section (24) is bent through a sharp angle in the direction of the flow and is preferably provided with at least one passage opening (10), e.g., comprising a number of round passage openings and/or at least one passage slot.

10. A device according to the foregoing claims 4-9, characterized in that, in the direction of the flow, below the level of the separation layer (6), the tank (1) is provided with a perforated baffle (26), provided with a number of perforations (27) to promote the laminar flow pattern in the upper part of the tank (1) for the separation of the upper flow (5), whereby those perforations in themselves are closed, in the form of, e.g., round, oval or rectangular slots, or they diverge in the direction of flow (V), e.g., toothing (28) or in the form of a triangle which is in itself closed, the apex of

- 18 -

which points against the direction of flow (V).

- 5 11. A device for the continuous separation of one floating lighter material component from a second heavier material, as in, e.g., the separation of oil contamination from water, while using a method and device according to one or more of the foregoing claims, characterized in that the flow discharge of separated lighter material is determined by positioning one movable valve unit (32) and the flow discharge of the cleaned material is determined by positioning a movable second valve unit (33).
- 10 12. A device according to claim 11, characterized in that each movable valve unit (32, 33) is connected to a fixed transverse section of the tank (31), a baffle or rear wall respectively, by means of a hinged joint.
- 15 13. A device according to claim 12, characterized in that the hinged joint is formed by an oblong, flexible strip (48) of material, particularly of an elastomer (rubber), which is sealingly (50) along one of its long sides to the fixed transverse section of the tank (31), while the other long side is sealingly to a stiff strip-shaped valve unit (51).
- 20 14. A device according to claim 13, characterized in that the movable seal, along the height of the valve unit (32, 33), between the side wall and the transverse section of the tank, is formed by the hinged strip (48) of the elastomer material that runs sideways over the total length of the valve unit to the side wall of the tank (31).
- 25 15. A device according to claim 14, characterized in that an extra strip of sealing elastomer material is interfitted at the position of the side wall between the movable ends of a valve unit and that fixed side wall, over the height of the valve unit, the rigidity of which only extends to some distance away from that side wall.
- 30 16. A device according to claim 15, characterized in that the hinged seal of the valve unit (32, 33) to the transverse section of the tank (31) as well as the seal (50), between the side wall and the valve unit (32, 33), are formed by one strip (48) of the elastomer material with the same height as the valve unit (32, 33), which strip has a length that at least corresponds with the total length of the valve unit (32, 33), increased with the

- 19 -

valve's free distance of travel from the top of the valve unit (32, 33).

17. A device according to one of the foregoing claims 11-16, characterized in that means (54, 57) are provided to adjust the position of both valve units (32, 33) separately and with respect to each other.

18. A device according to claim 17, characterized in that once both valve units (32, 33) have been adjusted in their relative positions they can be operated by means of one common adjustable coupling unit (56).

19. A device according to claim 18, characterized in that the adjustment of the coupling unit (56) is attained by means of a float (58), whereas after the tank (31) the cleaned second material component flows into an extra container (60), the level of which is then affected by the float (58) and the position of a valve unit (32, 33) connected to it.

20. A device according to claim 11, characterized in that, for the removal of any blockages near the bottom (36) of the tank (31), a baffle (34) is provided with a number of passage openings (D) located next to each other, whereby each opening is formed out of the baffle sheet material, i.e. by making a vertical cut X and then bending the sheet outwards on both sides of the cut, along the fold lines Z, over the distance Y, in the direction of flow, in order to create a triangular self-cleaning passage opening (D).

21. A device according to claim 11, characterized in that a sheet-form section of the tank (31) or of a valve unit (32, 33) is constructed with either a double or a single wall, and a heating element, particularly a sheet-form heating element (71) is mounted upon the single wall or located inside the double walls respectively, particularly a steam-heated element or an electric heating element.

22. A device according to claim 11, characterized in that means (A) are provided in the form of a slowly rotating scraper unit, particularly a sweeping brush (69), which has the purpose of removing any undesired accumulation of larger particles in front of the valve unit (32'), in the event a floating layer in a compartment of the tank (31) does not

- 20 -

have a uniform composition, by stopping the accumulation of particles near the top side of a valve unit (32'), which means are furthermore mounted in such a way that these particles are not swept past or over the greatest height of the said valve unit.

5

SUBSTITUTE SHEET

- 21 -

23. A device for the continuous separation of one floating lighter material component from a second heavier material, as in e.g. the separation of oil contamination from water, while using a method and device according to claim 11, characterized in that at least one float adjusted movable valve (132) is located  
5 in an upstream flow direction in the device (131) whereas at least one fixed baffle (134) is positioned in a downstream flow direction of said float adjusted valve (132) and the top sections (137, 143) of adjacent fixed baffles (134, 140) being positioned at different heights, the first top section (134) being positioned slightly higher ( $\delta h$ ) than the adjacent next top section (143) in a downward direction of  
10 flow.





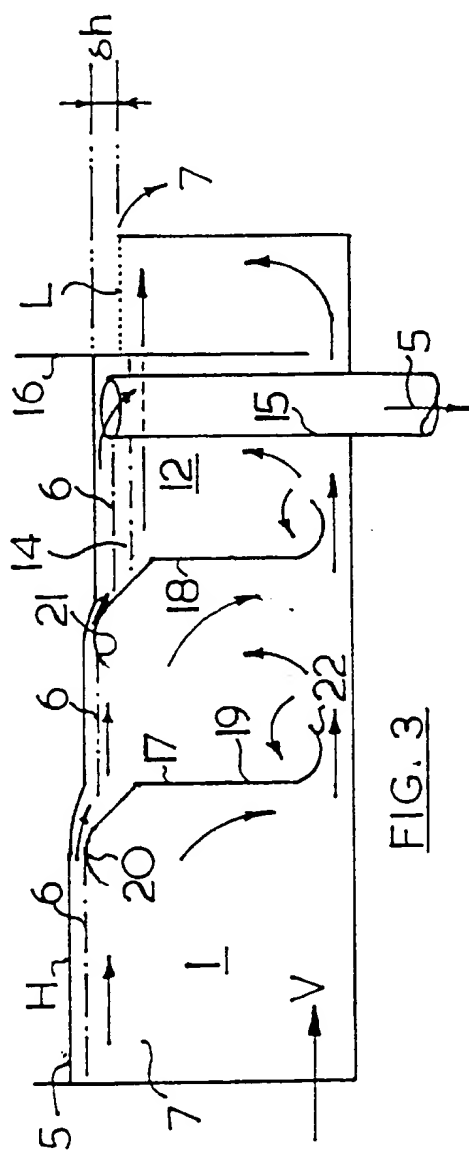


FIG. 3

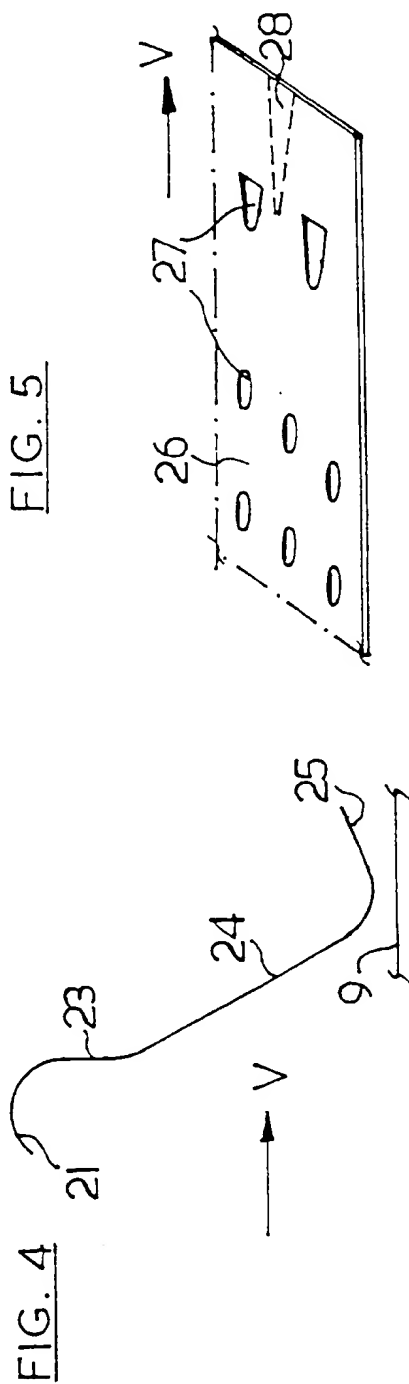
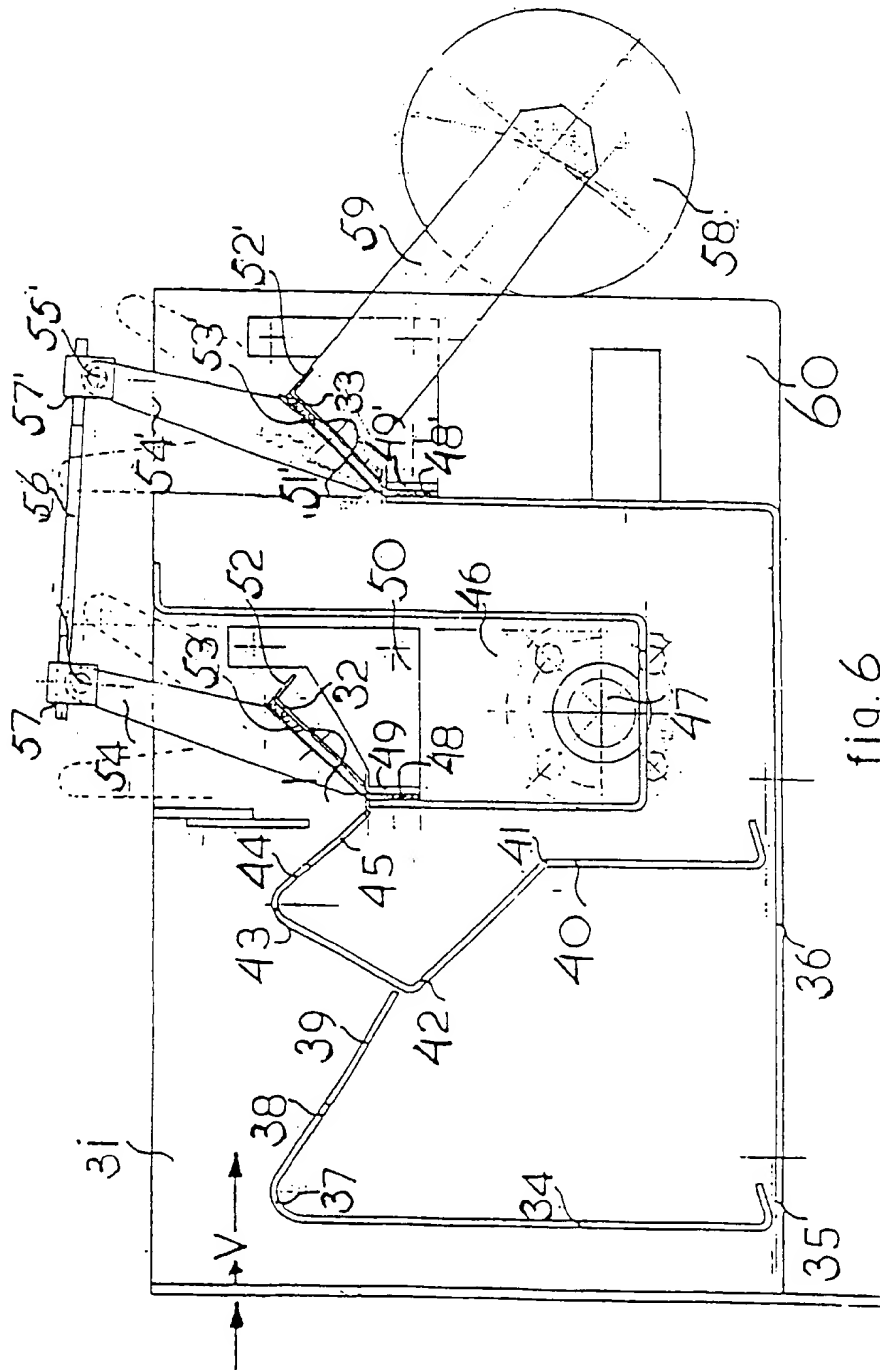


FIG. 5



4/9

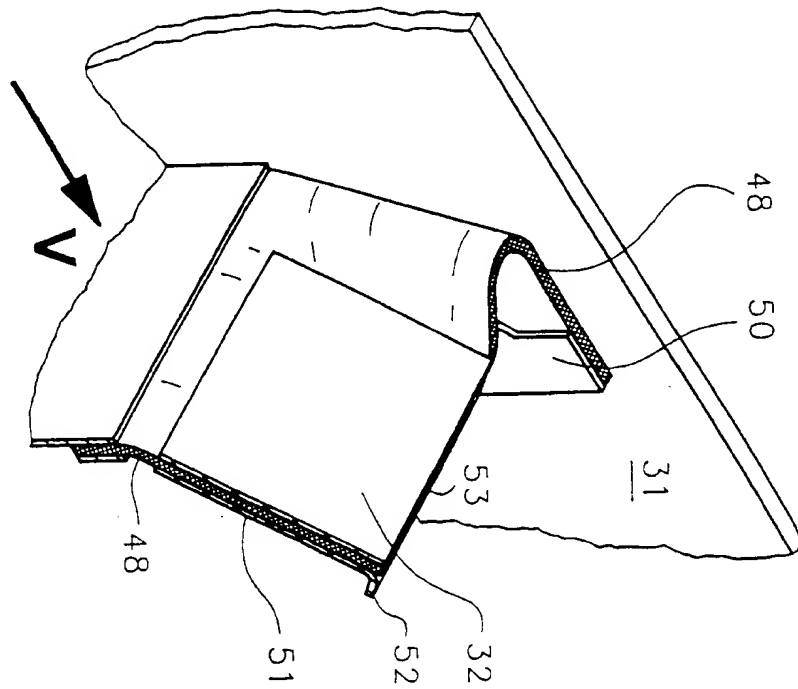


fig. 10

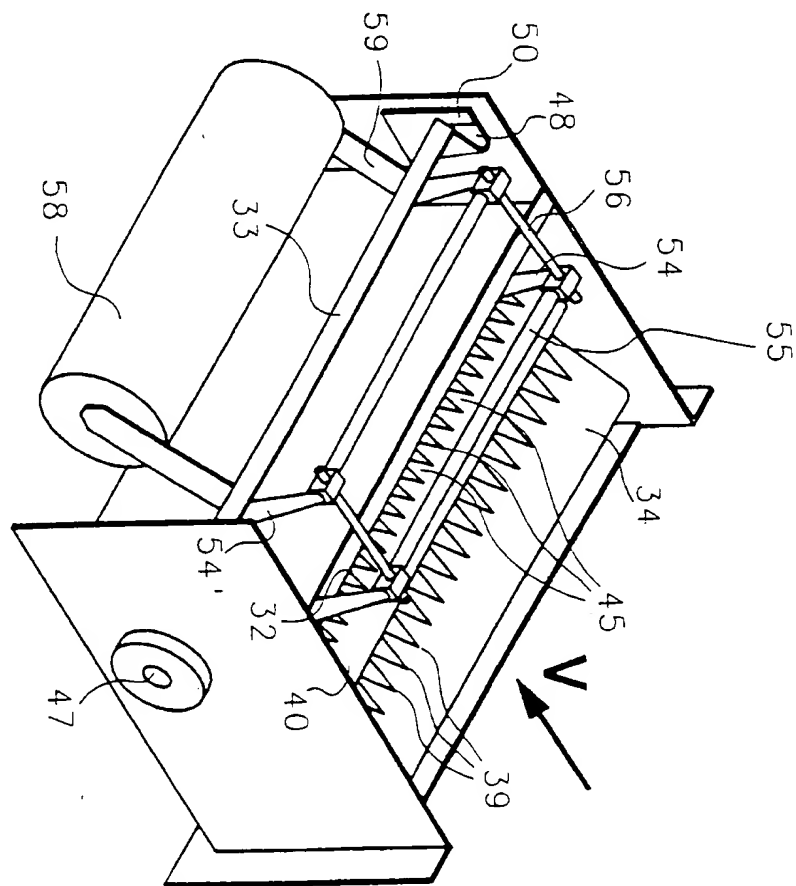


fig. 7

SUBSTITUTE SHEET

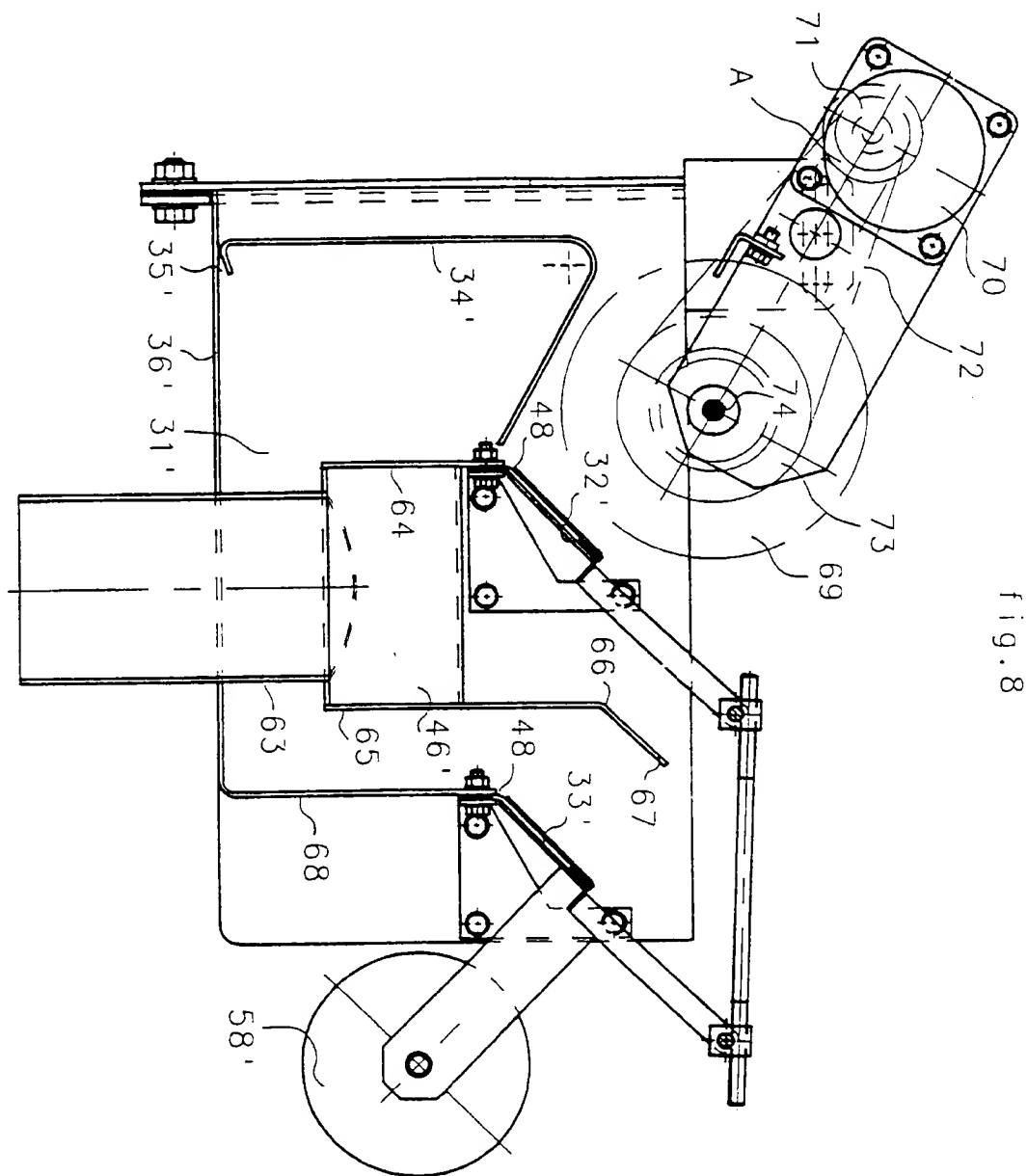


fig. 8

SUBSTITUTE SHEET

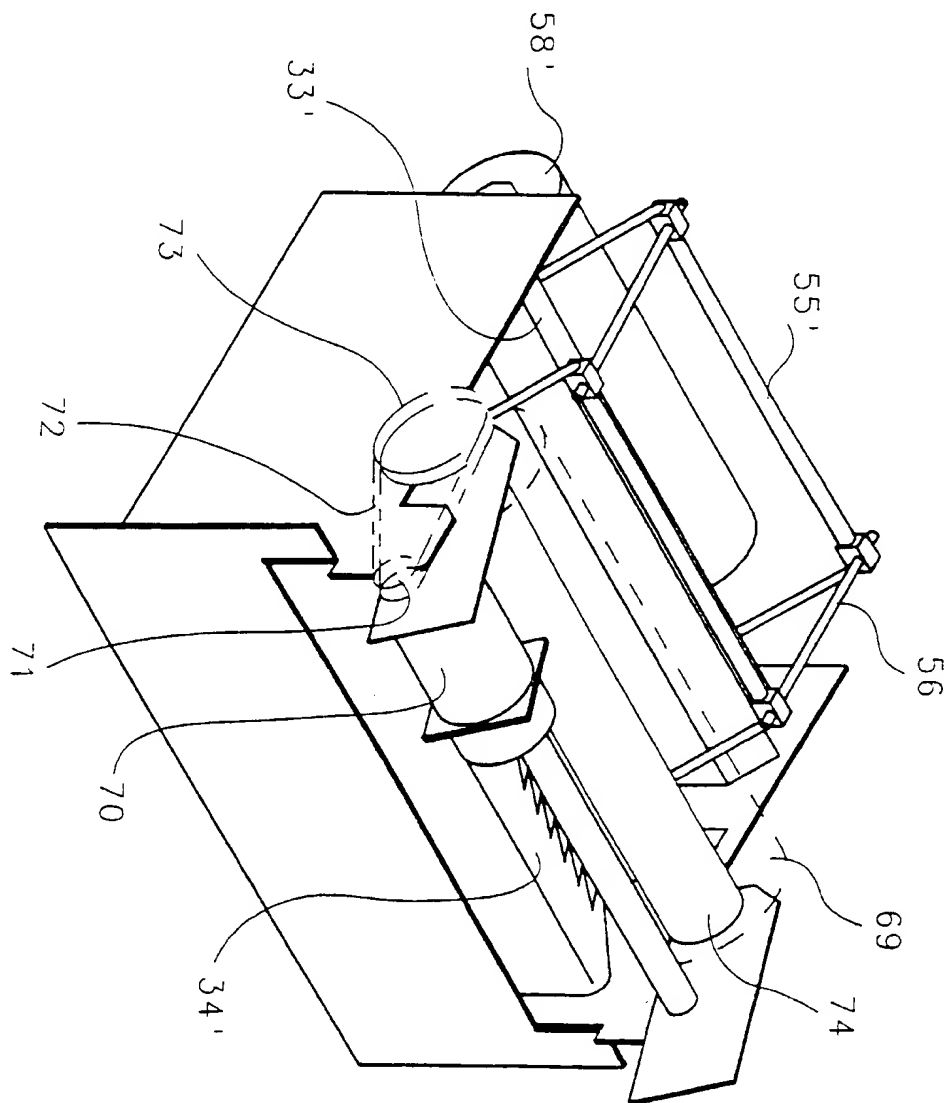


fig. 9A

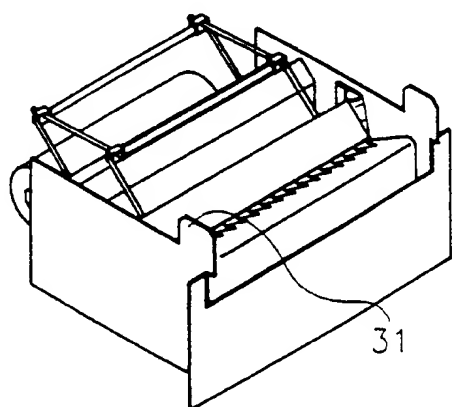


fig. 9B

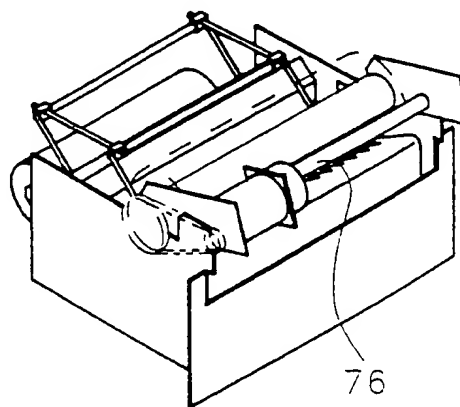


fig. 9C

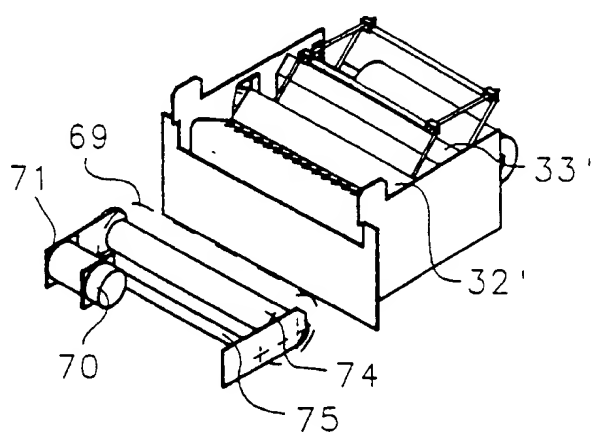
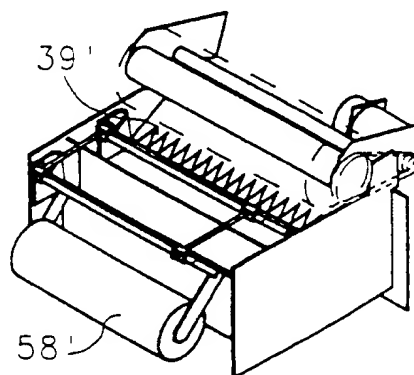
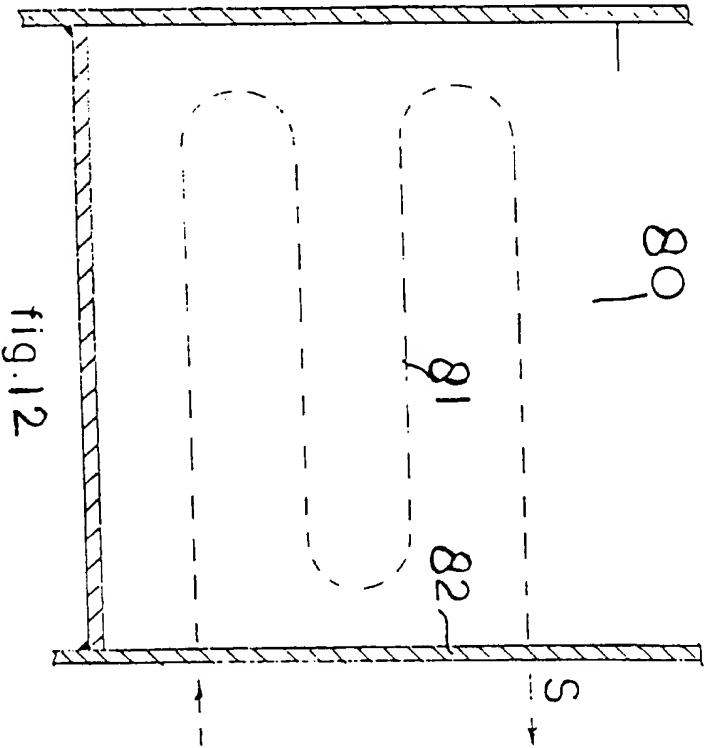
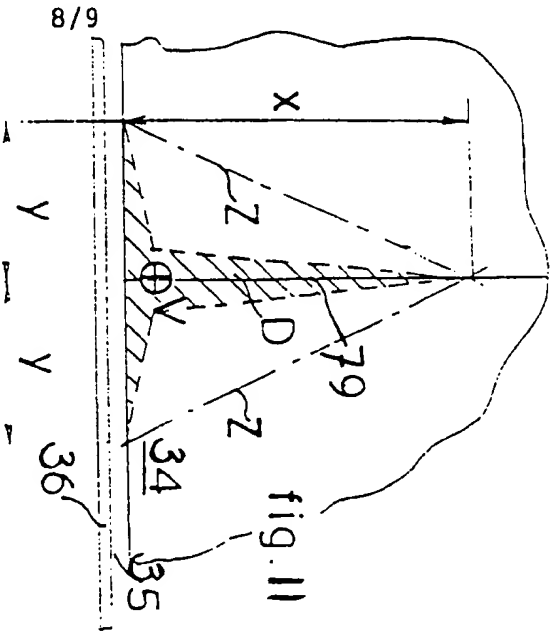


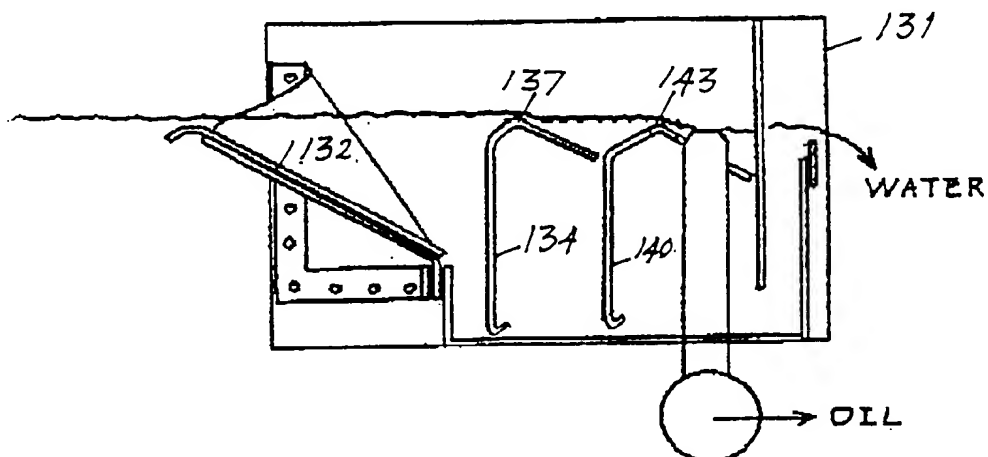
fig. 9D





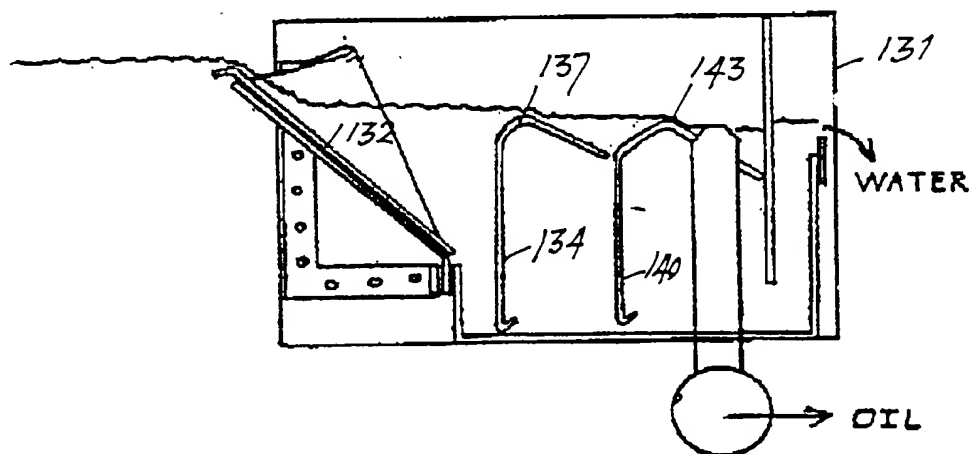
WATER AT LOWEST LEVEL

FIG. 13



WATER AT HIGHEST LEVEL

FIG. 14





## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/EP 93/02289

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC <sup>5</sup> : C 02 F 1/40, B 01 D 17/028, E 03 F 5/16		
II. FIELDS SEARCHED		
Minimum Documentation Searched <sup>7</sup>		
Classification System <sup>1</sup>	Classification Symbols	
IPC <sup>5</sup>	B 01 D 17/00, B 01 D 21/00, C 02 F 1/00, E 03 F 5/00	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
III. DOCUMENTS CONSIDERED TO BE RELEVANT <sup>9</sup>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with Indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
A	DE, A1, 3 702 482 (HAMMERSCHMITT) 11 August 1988 (11.08.88), claims 1,10,11; figs. --	1, 3, 4, 11
A	DE, A1, 3 516 895 (HAMMERSCHMITT) 13 November 1986 (13.11.86), claims 1,4,8; fig. 1. --	1-3,9
A	DE, A1, 3 732 136 (HAMMERSCHMITT) 06 April 1989 (06.04.89), claims 1,5; fig. 1. --	1-3
A	US, A, 4 132 652 (ANDERSON et al.) 02 January 1979 (02.01.79), claim 1; fig. 1. --	1,2
A	US, A, 4 064 054 (ANDERSON et al.) 20 December	1,2
<p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"Z" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
29 December 1993	18.01.94	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	PUSTERER e.h.	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, ** with indication, where appropriate, of the relevant passages	Relevant to Claim No.
	1977 (20.12.77), claim 1; fig. 1. --	
A	US, A, 4 400 274 (PROTOS) 23 August 1983 (23.08.83), claim 1; fig. 3. --	1,2
A	DE, A1, 3 303 632 (HAMMERSCHMITT) 09 August 1984 (09.08.84), claim 1; fig. 1. --	1,2
A	WO, A1, 90/14 874 (HAMMERSCHMITT) 13 December 1990 (13.12.90), claim 1; fig. 1. --	1,2
A	DE, C2, 2 837 554 (HUNKEL) 19 July 1984 (19.07.84), claim 1; fig. 1. --	1,2
A	DE, C1, 3 823 664 (GUSS- UND ARMATURENWERK KAISERSLAUTERN NACHF. KARL BILLAND GMBH & CO.) 22 February 1990 (22.02.90), claim 1; fig. 1. --	1,2
A	GB, A1, 2 216 821 (PONT-A-MOUSSON SA) 18 October 1989 (18.10.89), claim 1; fig. 2. ----	1

## ANHANG

## ANNEX

## ANNEXE

zum internationalen Recherchen-  
bericht über die internationale  
Patentanmeldung Nr.

to the International Search  
Report to the International Patent  
Application No.

au rapport de recherche inter-  
national relatif à la demande de brevet  
international n°

PCT/EP 93/02289 SAE 79963

In diesem Anhang sind die Mitglieder  
der Patentfamilien der im obenge-  
nannten internationalen Recherchenbericht  
angeführten Patentedokumente angegeben.  
Diese Angaben dienen nur zur Unter-  
richtung und erfolgen ohne Gewähr.

This Annex lists the patent family  
members relating to the patent documents  
cited in the above-mentioned inter-  
national search report. The Office is  
in no way liable for these particulars  
which are given merely for the purpose  
of information.

La présente annexe indique les  
membres de la famille de brevets  
relatifs aux documents de brevets cités  
dans le rapport de recherche inter-  
national visée ci-dessus. Les renseigne-  
ments fournis sont donnés à titre indica-  
tif et n'engagent pas la responsabilité  
de l'Office.

Im Recherchenbericht angeführtes Patentedokument Patent document cited in search report Document de brevet cité dans le rapport de recherche	Datum der Veröffentlichung Publication date Date de publication	Mitglied(er) der Patentfamilie Patent family member(s) Membre(s) de la famille de brevets	Datum der Veröffentlichung Publication date Date de publication
DE A1 3702482	11-08-88	AT E 75157 DE C0 3870264 DE C2 3702482 EP A2 276861 EP A3 276861 EP B1 276861	15-05-92 27-05-92 10-09-92 03-08-88 30-11-88 22-04-92
DE A1 3516895	13-11-86	AT E 55705 DE C0 3673553 EP A2 201072 EP A3 201072 EP B1 201072	15-09-90 27-09-90 12-11-86 30-12-86 22-08-90
DE A1 3732163	07-04-88	keine - none - rien	
US A 4132652	02-01-79	CA A1 1106295	04-08-81
US A 4064054	20-12-77	CA A1 1106294 DK A 4619777 DK B 149691 DK C 149691 GB A 1571637 NO A 773521 NO B 146015 NO C 146015	04-08-81 23-06-78 08-09-86 30-03-87 16-07-80 23-06-78 05-04-82 28-07-82
US A 4400274	23-08-83	keine - none - rien	
DE A1 3303632	09-08-84	AT E 39627 DE C0 3475879 DE C2 3303632 EP A2 118021 EP A3 118021 EP B1 118021	15-01-89 09-02-89 04-10-90 12-09-84 09-07-86 04-01-89
WO A1 9014874	13-12-90	DE A1 3930226 DE C2 3930226 AT E 93739 CA AA 2033321 DE C0 59002554 EP A1 429593 EP B1 429593 HU A0 905201 HU A2 58213 HU B 207235 IL A0 94654 US A 5151185 DD A5 294871 DE A1 3918343 DE C2 3918343	31-01-91 26-08-93 15-09-93 07-12-90 07-10-93 05-06-91 01-09-93 28-08-91 28-02-92 29-03-93 15-04-91 29-09-92 17-10-91 13-12-90 05-08-93
DE C2 2837554	19-07-84	DE A1 2837554	06-03-80
DE C1 3823664	22-02-90	keine - none - rien	
GB A1 2216821	18-10-89	AT A 204789 AT B 395411 BE AD 1005311 CH A 678438 DE U1 8901335 DK A0 411789 DK A 411789	15-05-92 28-12-92 29-06-93 13-09-91 27-04-89 30-01-89 09-08-89

FI A0 890548 06-02-89

FI A	890548	09-08-89
FR A1	2626782	11-08-89
FR B1	2626782	08-06-90
GB A0	8902315	22-03-89
GB B2	2216821	18-09-91
GR E	1000366	30-06-92
IT A0	8967060	02-02-89
IT A	1232388	17-02-92
LU A	87445	14-06-89
NL A	8900291	01-09-89
NO A0	890472	06-02-89
NO A	890472	09-08-89
PT A	89625	04-10-89
SE A0	8900338	01-02-89
SE A	8900338	09-08-89
SE B	469283	14-06-93
SE C	469283	07-10-93

---